CHAPTER 6

Geoarchaeology of the Lower Colorado River International Boundary Section

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Geoarchaeological investigations were undertaken at the request of USACE and the IBWC. The purpose of this testing was to develop a predictive model for identifying areas within the APE that might contain previously unidentified cultural resources. This work was accomplished by systematically excavating 21 backhoe trenches within the APE, coupled with the detailed examination, recording, and interpretation of the trench exposures. Particular attention was paid to sedimentary structures (e.g., cross-bedding, planar bedding, etc.), sediment textures (e.g., coarse sand, fine sand, silt, clay, etc.), soil attributes, and the relationships between these and the historically documented locations of the lower Colorado River's main channel.

The following discussion starts with a description of the processes and features that typify a meandering river system such as the lower Colorado River. This is followed by a synthesis that documents the locations and actions of historically documented lower Colorado River channels. The geoarchaeological methods applied during the course of this study and their results are then discussed. General principles of site formation and preservation in a riverine setting are presented. These discussions, along with a discussion of the general principles of site formation and preservation, are then used to develop a model that will serve to determine the locations within the APE that may yield cultural resources.

Fluvial Facies Model

There are two faces to the lower Colorado River. During most of the year, the Colorado is a calm river, meandering across its wide valley. During flood episodes, normally peaking from May to July, the Colorado overflows its banks and temporarily forms a broad anastomizing river with shallow subsidiary channels separated by emergent bars. As flood waters recede, sediment is deposited on the floodplain and refills the channels. When normal flow is restored, the river usually reverts back to its normal meandering pattern within the newly created channel. After the Colorado River flows through the narrow pass between Yuma and Pilot Knob it expands its channel onto the Colorado River delta, a broad valley bordered by the 20-m-high bluffs of Yuma and Sonora Mesa to the east and the Cocopah Mountains to the west. In the nineteenth century, this channel was 1/8–1/2 mile wide and 8–20 feet deep (Ives 1861:9), defined by natural levees stabilized by coarse grass and tule (Sykes 1937:30–31). Presently, after construction of artificial levees between 1907 and 1911 to restrict lateral movement and damning of the river to divert water for agriculture, the Colorado represents a lower discharge version of its former self, residing in a channel too wide for its current flow.

The Colorado River depositional cycle can be characterized by the fine-grained, meandering assemblage, fluvial-facies model of Miall (1996) (Table 3). Sedimentary facies in this model consist of coarser grained, sand-filled channel and crevasse splay deposits, and finer grained overbank and levee deposits. These facies can often be readily identified on topographic maps and aerial photographs, and the events

Table 3a. Fluvial Facies Components

Facies	Lithofacies	Interpretation
Active channel deposits	Fl, St, Sr, Ss	channel fill, point bar deposits
Natural levee deposits	Fl, Sr	overbank flooding
Overbank deposits	Fl, Fm, Fr, Sr	overbank flooding and sheet flow
Abandoned channel deposits	Fl, Fsm, Fm, Fr	fill of abandoned channels

Table 3b. Lithofacies Codes

Lithofacies Codes	Sediment Size	Features and Sedimentary Structures
Fl	sand, silt, clay	fine lamination, very low ripple cross-lamination
Fsm	clay, silt	massive
Fm	clay, silt	massive, dessication cracks
Fr	clay, silt	massive, bioturbated
Sr	sand	small-scale ripple cross-lamination
St	sand	large-scale trough dune cross-beds
Ss	sand	low-angle cross-beds

Note: Modified from Miall (1996:Table 1).

that created them may be found in the historical literature of the Colorado River. The meandering river facies model contains four major elements: active and abandoned channels, crevasse splays and crevasse channels, natural levees, and floodplain deposits (Figure 27).

Active and Abandoned Channels

Active channels are filled primarily by cross-bedded, point bar deposits consisting of medium-to-coarse sands along with the coarsest bed material that tends to be confined to the bottom of channels. The

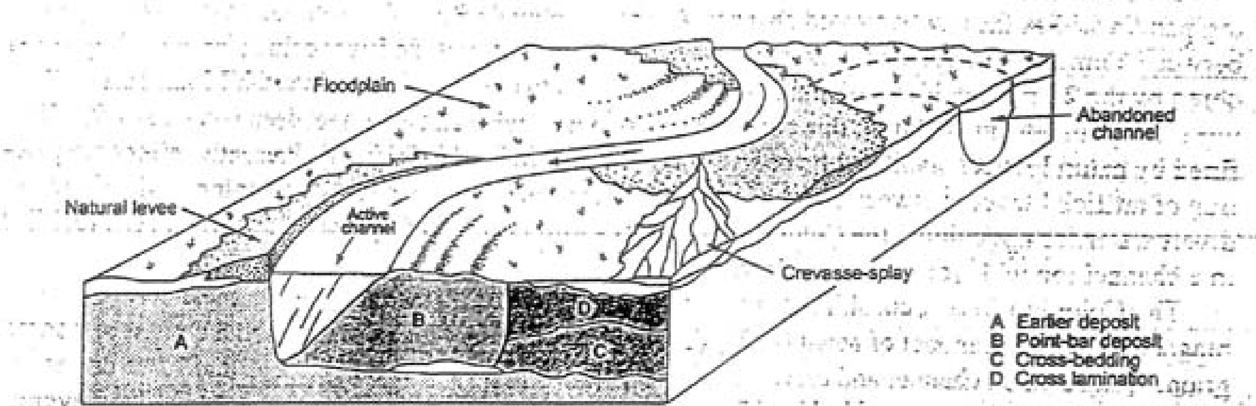

Figure 27. Summary facies model for a meandering river (adapted from Collinson 1978:33).

coarse-bed material ("lag") moves slowly, mostly during floods, and accumulates in the bottoms of deep scours. Such lag is particularly characteristic of meandering channels, resulting primarily from bank erosion. It may include clasts of overbank mud and waterlogged plant debris along with the coarsest bed-load sediment.

A meandering river like the lower Colorado River has an asymmetric channel, sloping gradually from the inner convex to the outer concave bank. The outer bank is steep where the river is deeper and faster moving. The inner slope rises gently to form an emergent wedge of sand, the point bar, where the river's flow is slower. Point bar deposits are partially composed of the coarsest sediment available in a river. If a wide range of grain sizes are available, grain sizes decrease upward in a point bar sequence. Generally, a muddy or very fine-grained layer is present on the top as a thin veneer. If present, this mud drape marks the top of a flood episode. However, the uppermost fine-grained part of a point bar sequence may be eroded before the deposition of the next sequence. Thus, only incomplete sequences are often preserved. A major part of a point bar sequence is deposited during floods, especially when the water starts receding, and the rate of deposition can be very high. In the meandering stream of normal flow, sediment slumped into the channel by outer-bank caving is caught by the current and deposited on the point bar on the next downstream meander. In this manner the river's shape slowly changes as concave banks and point bars slowly migrate laterally across the floodplain (Reineck and Singh 1973:228).

The shape of the Colorado River channel is more drastically altered during flood stages. This modification is a two stage process involving first erosion and then deposition into the newly formed channel. During flood episodes, discharge may be great enough to completely fill the channel to its vegetation stabilized margins and overflow its banks. Sykes (1937:55) observed that during the normal flood event of 1905 the entire region Pilot Knob and the head of tidewater was under water. He could find no dry ground until he reached the escarpment of the Sonoran Mesa south of the international border. During this and other major flood events water probably reached as far as the bluffs 10 km east of the current channel. The shape of the channel also changes as increased discharge promotes downward and lateral erosion of the original channel. For example, the leveed Colorado River at Yuma dramatically increased in depth (by nearly 20 feet) and width (by 100 feet) during a single flood pulse in 1916 (Lane and Borland 1954:1076, Figure 4). These authors also recorded the cross-section profile of the same stretch during a smaller flood episode from May to July 1929. Between mid-May and mid-June the channel depth increased by over 10 feet, only to be refilled by mid-July. The shape of the bottom before and after the flood changed only slightly but would be more dramatic of the river could have migrated laterally instead of cutting downward with the increased discharge. Since the implementation of the artificial levees has restricted this lateral migration, the sediments within the valley (between its leveed banks) are effectively replaced with each major flood. Based upon flow records for the Colorado River at Yuma, before the river's discharge was drastically reduced with the construction of Hoover and other dams upstream after 1935, a major flood event probably occurred once every two years.

Channel meander loops are periodically abandoned during flood events forming abandoned channel segments or oxbow lakes. Channel abandonment and oxbow lake formation take place by the processes of neck cutoff or chute cutoff. Neck cutoffs occur when the concave banks of adjacent channel meanders merge, resulting in the sudden abandonment of an entire meander loop. The new channel quickly plugs each end of the abandoned loop with active channel sediments and an oxbow lake is formed. Once created, an oxbow lake receives suspended sediments (silts and clays) only during overbank flooding episodes. Repeatedly overbank flooding, and the settling of fine-grained sediments within the oxbow, creates a depositional sequence containing channel lag sediments overlain by a thick sequence of flood-deposited silts and clays. Chute cutoffs occur when a river erodes a channel, or chute, into the proximal portion (i.e., the thickest segment furthest away from the main channel) of a point bar surface. As the resultant chute captures the majority of the channel flow, the older channel slowly fills with lag material and forms an oxbow lake.

Oxbow lakes are particularly characteristic of confined, highly sinuous, rivers. Filled with fine-grained, highly cohesive, overbank sediments, oxbow lakes resist erosion. Subsequently, oxbow lake sediments further restrict the river's natural tendency to migrate laterally across its floodplain. Continued deposition is then confined to the active channel which increases its elevation and creates especially large levees (or alluvial ridges) situated above the level of the surrounding floodplain. When a levee is breached in this scenario, water from a large segment of the meander belt funnels into the lowest accessible portions of the floodplain. This process (avulsion) results in the abandonment of the old meander belt and in the formation of a new channel.

Crevasse Channels and Crevasse Splays

Crevasse channels, and their associated crevasse splays, represent breaches through the natural levee of the meandering river channel into the adjacent floodplain during periods of high discharge. Crevasse channels have formed particulary towards the west historically—the most prominent in 1905 when the river breached the intake of a small canal built in 1901 spilling out to the west and north and filling the Salton Trough. Another break was documented by Sykes (1937:39) near the Arizona-Sonora border in 1891, when floodwaters flowed westward to the Alamo and Paredones drainage systems of the lower Imperial Valley in Baja California. Crevasse channel deposits are ribbonlike bodies consisting mainly of trough cross-bedded and ripple cross-laminated sands. The coarsest sediments are equivalent in grain size to the main channel sediments.

While crevasse splays may involve erosion, they are primarily an overbank sedimentary cover similar in shape to a small delta. Depending upon discharge, individual crevasse splays may be a few centimeters to many meters thick and can reach a 100 m or more across (Miall 1996:171, Table 7.1). Thicker sequences are usually indicative of previous erosion. The deposits of crevasse splays typically consist of fine- to medium-grained sands and trough cross-bedding and cross-lamination are particularly common attributes of crevasse splay deposits. Decreased grain size away from the main channel and upward fining distinguish typical splay deposits.

Because the Colorado delta slopes west as well as south, breakouts into the floodplain as crevasse channels were probably always more significant to the west. However, the documented channeled features found far to the east of the current channel may also represent past crevasse channels into the Arizona side of the delta. Although crevasse channels and crevasse splays are a significant feature of meandering rivers, their recognition is determined primarily by their 3-D geometry. Their lithofacies are generally similar to that of active channel and overbank deposits.

Levees

Natural levees are one of the most prominent features of a meandering river floodplain. They are wedge-shaped ridges of clastic sediment that form immediately adjacent to the channel on both banks of meander loops. Levee deposits are fine-grained mantles at the margins of the active channel, formed incrementally as the river overflows its banks during flood episodes. During each flooding, a layer of ripple-laminated and/or horizontally laminated sand, silt, and clay (usually a few decimeters thick) accumulates. These deposits slowly build up a natural embankment. Later root development and rodent activity commonly obscure lamination and abundant vertebrate remains may be present. Because levees are exposed most of the time, they are commonly heavily vegetated, contain abundant plant debris, and often undergo soil formation processes.

Floodplain Deposits

Floodplain fines (fine sands, silts, and clays) are deposited during waning flood stages as thin drapes over high points, abandoned channels, and other low areas. They often consist of very fine sands, silts, and muds carried in suspension and deposited either close to the channel margin or in low points (e.g., oxbow lakes) on the floodplain. Depending on grain size these beds may be planar-bedded to massive and may show dessication cracks. These beds are typically disturbed by root activity making recognition of sedimentary structures difficult in trench profiles. Away from the channel, a few millimeters or centimeters of sediment are normally deposited by a single flood and, although initially laminated, the lamination is soon destroyed by plant roots or soil formation. In arid regions like the lower Colorado River valley, thin beds, nodules, and filaments of evaporite minerals (e.g., gypsum and calcium carbonate) are common constituents of floodplain deposits.

Since construction of upstream dams in the 1930s and 1940s have restricted discharge, overbank flooding episodes have diminished and recent natural levee and floodplain deposits probably have not been significant. Consequently, soil formation processes dominate the modern floodplain.

Historic Colorado River Channels

The channel configuration of the lower Colorado River has been intermittently documented for the last 150 years, with the greatest detail and frequency occurring in the early twentieth century. Figure 28 shows the accumulated pattern of channels for the period 1852–1915, and Figure 29 shows the pattern in the valley after completion of the artificial levees in 1915. Examination of the earlier maps shows the patterns of migration of the river from its current course eastward, onto the Yuma Valley, prior to the construction of levees. These patterns indicate the areas where cultural material would not be expected to be recovered in situ because of the process of channel scouring and backfilling. Evidence of these remnant channels can still be seen on USGS 7.5-minute series topographic maps or aerial photographs as arcuate-shaped features in the Yuma Valley east of the levee. Although the age of these features is unknown but they are probably Late Holocene to recent. Historic abandoned channels can also be seen in the Colorado River floodplain north of the international border both on topographic maps and on the surface.

Sedimentary facies indicative of previous channels include sand-dominated, scour fill, ripple cross lamination, and larger 3-D scale trough dune scale cross-bedding such as that observed in the trench samples taken in the reach of the Fort Yuma Indian Reservation disposal area northwest of Yuma (Huber et al. 1998). We would anticipate finding similar sedimentary features in trenches excavated in the Colorado River delta south of Yuma, but we would expect to recover prehistoric or historic materials only in those areas not affected by known flooding events.

Site Modeling along the Lower Colorado River

A meandering river environment, like the lower Colorado River, is highly dynamic, with different areas of the floodplain characterized by erosion, deposition, and stability through time. As a river migrates laterally and downstream, it is constantly forming a new floodplain by reworking the older floodplain sediments. Normal stream flow is responsible for erosion along the channel banks, deposition in the channel, and the lateral downstream migration of the river. Sediments in areas away from the channel, such as those of the floodplain or inactive terraces, are more permanently stored and may remain stable for long

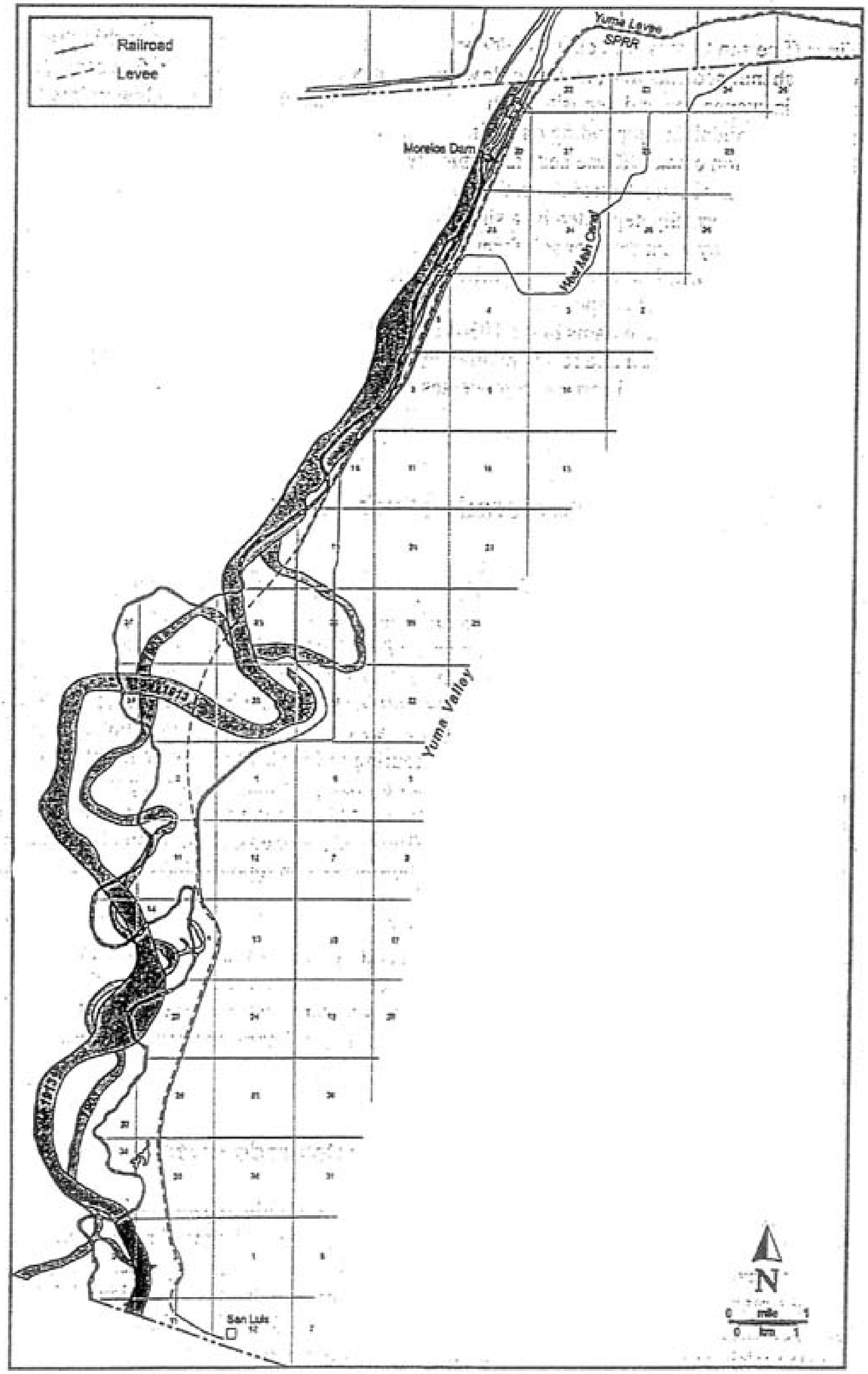

Figure 28. Documented channel meanders for the Colorado River before 1915.

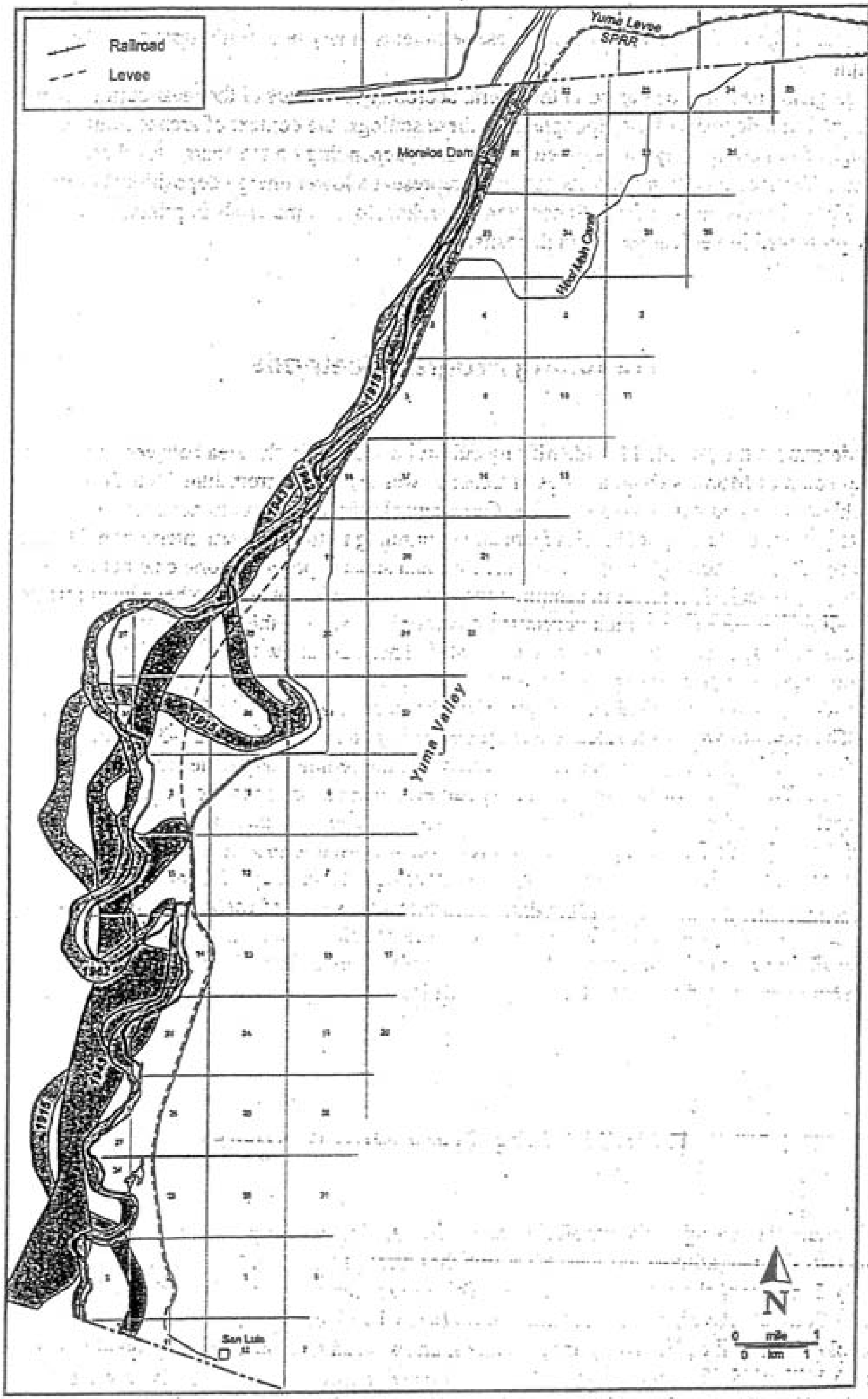

Figure 29. Documented channel meanders for the Colorado River after 1915.

periods of time. However, the river can erode these sediments at any time if it migrates or down-cuts into its floodplain.

Archaeological sites may be buried in the lateral accretion sediments of the meandering channel or in the vertical accretion deposits of the floodplain. In these settings, the context of archaeological sites theoretically ranges from completely undisturbed to modified, depending on the energy level associated with the deposition. Vertical accretion deposits generally represent a lower energy depositional environment compared to lateral accretion deposits. Subsequently, archaeological materials in primary context are more likely preserved in vertical accretion deposits.

Trenching Program Methods

In order to determine the potential for identifying cultural resources in the area between the Colorado River levees south of Morales Dam, a series of trenches was excavated from June 28 to July 1, 1999, using a backhoe equipped with a 2-foot bucket. Our original plan was to cut trenches at a spacing of approximately ½ mile, starting at Morales Dam and continuing to the southern international border. Working from USGS quadrangle maps onto which we had superimposed historic channel meander alignments, we were particularly interest in sampling those areas that did not seem to have been affected by historic flooding. Because of the thick vegetation cover or high water table in some areas and agricultural activity in other areas, only 21 trenches were excavated. These did show the complete diversity of geomorphic elements that would be expected in a meandering river fluvial system.

The location, orientation, length, and depth of the 21 trenches is shown in Table 4 and mapped on Figure 30. The trenches were excavated to a length of 9–21 m and a depth of 120–305 cm. In all cases, they were deep and long enough to enable us to determine the sedimentary facies represented. All of the trenches, except Trench 8 (oriented northwest to southeast, perpendicular to the west bank of an abandoned channel) were oriented within 25 degrees of east-west, approximately perpendicular to the flow direction of the Colorado River. A portable GPS receiver was used to plot the location of all trenches excavated onto a USGS 7.5-minute series map. A standardized form adapted from Birkeland (1999:Appendix 1) was used to record the soil properties and sediment textures of each exposed soil and/or lithofacies. Black-and-white prints and color slides were taken of selected trench profiles. Hand trowels were used to face all documented trench walls. Sediment samples were collected for additional postfield analysis. All trenches excavated were mechanically backfilled and compacted after profile recording was completed.

Results of the Trenching Program

Table 5 provides the setting, soils, lithofacies, and interpreted facies for each trench. Sampling was performed on two separate alluvial terraces. Most trenches were placed on a lower terrace, which lies approximately 5–6 meters above the river channel. This terrace represents the floodplain of the entrenched present-day Colorado River, its flow determined primarily by diversion above Morales Dam. The floodplain is choked with salt cedar (*Tamarisk pentadra*), arrow weed (*Pluchea sericea*), quail bush (*Atriplex lentiformis*), willow (*Salix gooddingii*), and cottonwood (*Populus fremontii*), and is accessible only by occasional roads and areas cleared by cut and burn. The vegetation associations in the areas sampled,

Table 4. Location, Orientation, Length, and Depth of Geomorphic Test Trenches

Trench	Quadrangle Map	Township and Range	Section	Quadrant	UTMs Northing	UTMs Easting	Orientation	Length (m)
1	Yuma West	T8S R24W	32	SE, SE	3618345	712182	295°	15
2	Yuma West	T8S R24W	5	SW, NE	3617601	711740	290°	21
3	Yuma West	T9S R24W	5	SW, NE	3617620	711704	275°	19
4	Yuma West	T9S R24W	5	SW, SE	3616734	711554	295°	9.5
5	Grays Well NE, Calif.-Ariz.	T9S R24W	18	SW, SW	3613475	709705	245°	16
6	Grays Well NE, Calif.-Ariz.	T9S R24W	19	NW, NW	3613026	709377	290°	10
7	Grays Well NE, Calif.-Ariz.	T9S R25W	24	NW, SE	3612493	709020	290°	9
8	Grays Well NE, Calif.-Ariz.	T9S R25W	24	SE, SW	3611723	708459	315°	17
9	Gadsden	T9S R25W	35	NW, NW	3610049	706152	260°	10
10	Gadsden	T10S R25W	23	SW, SW	3602059	706564	270°	10
11	Gadsden	T10S R25W	26	NE, SW	3600871	706783	285°	10
12	Gadsden	T10S R25W	35	NW, SW	3599487	706583	295°	9
13	Gadsden	T10S R25W	35	SW, NW	3599567	706660	272°	10
14	Gadsden	T10S R25W	35	SE, SW	3598745	706957	270°	10
15	Gadsden	T11S R25W	3	NE, NE	3598629	706380	255°	15
16	Gadsden	T11S R25W	3	NE, SE	3597831	706036	270°	9
17	Gadsden	T11S R25W	3	SW, SE	3597316	705880	270°	9
18	Gadsden	T11S R25W	2	SE, SW	3597305	707023	275°	8
19	Gadsden	T11S R25W	2	SE, NW	3597965	707156	260°	10
20	Yuma West	T8S R24W	28	SW, SE	3620286	713038	290°	10
21	Yuma West	T8S R24W	33	SW, SW	3618640	712330	275°	10

based upon the work of Anderson et al. (1984), include the Salt Cedar and *Atriplex* (dominated by quail bush) Association Types. Creosote (*Larrea tridentata*), honey mesquite (*Prosopis glandulosa*), screw-bean mesquite (*Prosopis pubescens*), and burro weed (*Ambrosia dumosa*) were also present. The second terrace—another 5–6 m above the first—probably represents an edge of the nineteenth-century pre-levee floodplain.

Three incipient soil types were represented in the trenches. Incipient desert A horizon aridisols were predominant in areas that have not been cultivated. There soils are generally weakly developed, ranging in depth from 20 to 70 cm. Agricultural soils ranging from 40 to 50 cm deep (with a weakly developed Ap horizon) were observed in five trenches. A single example of an incipient entisol was seen in Trench 18. This soil, 70 cm thick, developed in the clay-rich fill of an abandoned channel. In all trenches the soil zone was indicated by the general lack of sedimentary structures due to the development of soil structure, root disturbance, and invertebrate mixing. Burrows of small ground squirrels (*Ammospermophilus* sp.) and pocket gophers (*Thomomys* sp.) were observed on the surface, but their modification of the sediment structures is minimal.

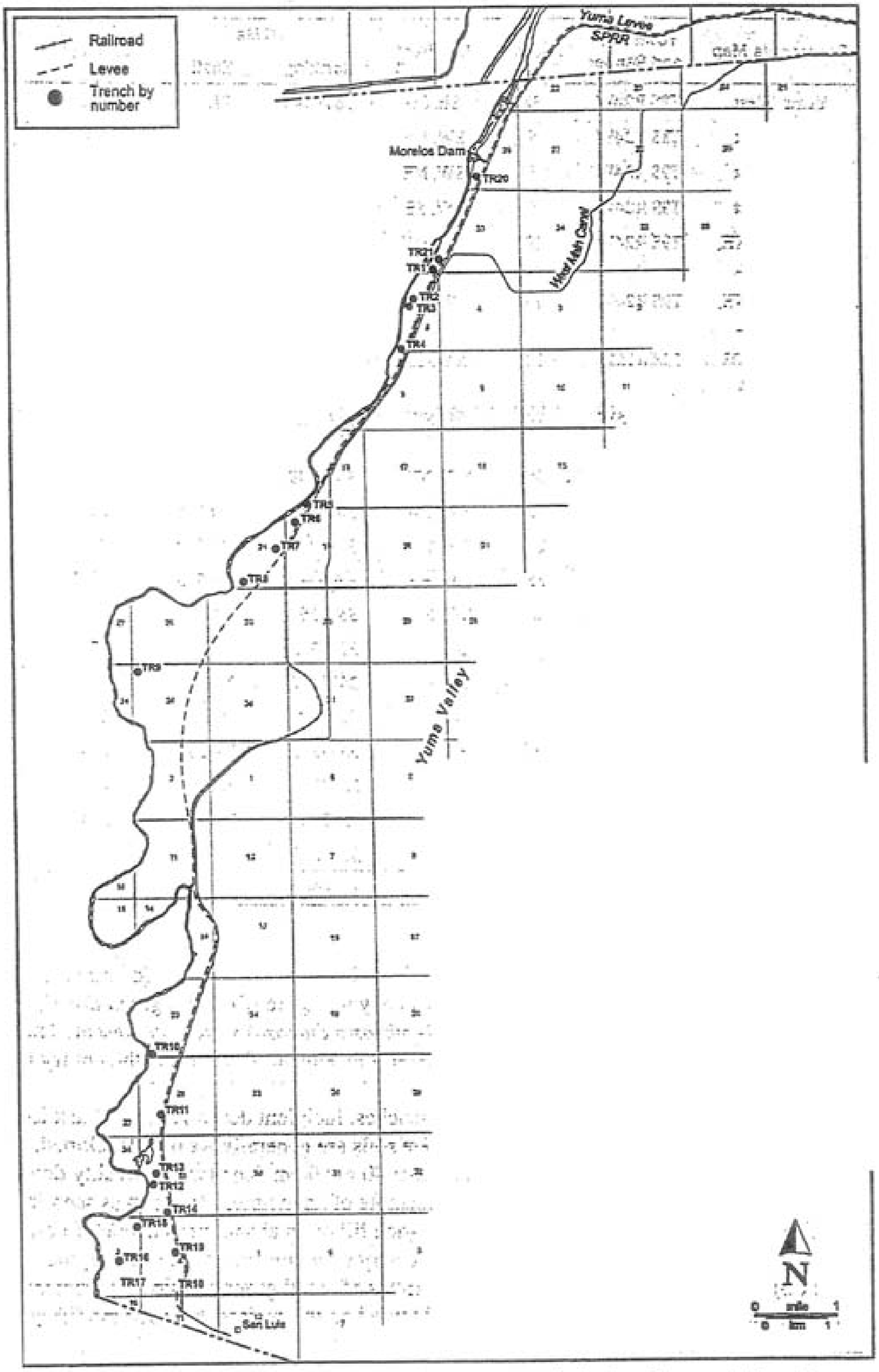

Figure 30. Location of backhoe trenches excavated during the modeling phase.

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Table 5. Setting, Soils, Lithofacies, and Interpreted Facies for Each Geomorphic Test Trench

Trench	Terrace	Total Depth (cm)	Nature of Surface	Vegetation Association	Soil Type	Depth of Soil Development (cm)	Grain Size	Lithofacies (see Table 3b)	Fining Upwards Sequence	Facies
1	second	185	cleared	*Atriplex*	Aridisol	70	very fine sand	Fl, Fr, Sr	no	proximal overbank
2	second	290	50% vegetated cover	*Atriplex*/creosote	Aridisol	50	very fine sand	Fl, Sr (climbing)	no	natural levee
3	first	150	80% vegetated	*Atriplex*	Aridisol	65	fine sand	Fl, Sr	no	proximal overbank
4	second	150	30% vegetated	arrow weed	Aridisol	30	fine sand	Fl, Sr, Sd, Ss	no	Point Bar Units 2–3
5	first	290	80% vegetated	salt cedar	Aridisol	40	clay to very fine sand, medium sand	Fl, Sr Sd	yes	Point Bar Units 3–5 Point Bar Unit 2
6	first	160	abandoned field	agricultural	agricultural	40	very fine sand	Fl	yes	proximal overbank
7	first	145	cleared	salt cedar	Aridisol	60	very fine sand	Fl, Sr	no	proximal overbank
8	first	305	abandoned channel	arrow weed	Aridisol	30	fine sand, medium sand, fine to medium sand	Fl, Sr Sd Ss	yes	Point Bar Units 4–5 Point Bar Unit 3 Point Bar Unit 2
9	first	120	burned, cleared	salt cedar	Aridisol	20	very fine sand	Fl, Sr	no	proximal overbank
10	first	120	burned, cleared	salt cedar	Aridisol	50	clay to very fine sand	Fl, Sr	yes	Point Bar Units 4–5
11	first	140	burned, cleared	salt cedar	Aridisol	20	clay silt to very fine sand	Fl, Fsm Fl, Sr	yes	abandoned channel proximal overbank
12	first	140	cleared	*Atriplex*	Aridisol	40	very fine sand	Fl, Sr (climbing)	no	natural levee
13	first	160	fallow field margin	agricultural	agricultural	50	clay to very fine sand	Fl, Sr	yes	Point Bar Units 4–5
14	first	160	fallow field margin	agricultural	agricultural	40	clay to very fine sand, clay to silt	Fl, Sr Fl, fsm	yes	proximal overbank historic channel fill
15	first	140	burned, cleared	salt cedar	Aridisol	30	clay to very fine sand	Fl, Sr	yes	abandoned channel
16	first	120	abandoned field	agricultural	Aridisol	50	very fine sand, clay to silt	Fl, Sr Fl, Fsm	no	Point Bar Units 4–5 historic channel fill
17	first	170	fallow field margin	agricultural	agricultural	40	clay to very fine sand	Fl, Sr	yes	Point Bar Units 4–5
18	first	240	burned, cleared	salt cedar	Entisol	70	clay to silt	Fl, Fsm, Fm	no	abandoned channel
19	first	140	burned, cleared	*Atriplex*	Aridisol	70	clay to fine sand	Fl	yes	proximal overbank
20	second	140	cleared	*Atriplex*	Aridisol	30	silt to medium sand	Fl, Sr	yes	Point Bar Units 3–5
21	first	140	fallow field margin	agricultural	agricultural	40	clay to very fine sand	Fl, Sr	yes	Point Bar Units 4–5

Four lithofacies were observed in the trench sediments representing point bar, natural levee, proximal overbank, and abandoned channel fill deposits. Point bar deposits formed by the lateral accretion in an active channel were observed in seven trenches. Most trenches showed only the upper two or three units of the five-unit point bar sequence and the lower unit, with no channel lag deposits observed. Natural levee deposits were observed in two trenches and proximal overbank deposits in eight trenches. Both of these facies represent deposits formed by vertical accretion onto lower areas in the floodplain above the active channel. Filled abandoned channels were observed in two trenches.

Sediment grain size was predominantly very fine sand, although fine and medium sand was observed at the base or edge of point bar deposits. Silt and clay occurred primarily in thin beds at the top of graded sequences and as laminated-to-massive overbank and channel fill deposits. Small rounded prolate pebbles up to 2 cm long were observed in the cross-bedded sands in Trench 8, representing the highest energy event observed in the survey.

With the exception of Trenches 3, 8, and 18, there appears to be no obvious relation between the facies and the configuration of the channel during any known flooding event. Trench 3 which had sediments suggestive of an overbank deposit, was located on the first terrace just behind the natural levee, the natural environment for floodplain deposition. Trench 8 was cut into the 2.5 m west bank and bottom of a recently abandoned and unfilled channel, the natural setting for the point bar deposit that was observed in the trench. Examination of the flood map mosaic indicates that this channel may represent an oxbow formed by cutoff of the channel formed by the flood event of 1913. Trench 18 represents the fill of a similar abandoned channel, probably the channel meander observed on the 1915 map. This channel has subsequently been isolated and has been filled with fine grained sediment so that no surface evidence of the channel exists today.

The results of the trenching program have served to reemphasize the complexity of a meandering river system. The unpredictable nature of erosion and deposition is well displayed by the difference in depositional history of the two once-active channels in the vicinity of Trenches 8 and 18. Both of these channels were active in the early twentieth century, but the channel identified in Trench 18 has been completely filled, while the channel of Trench 8 remains open, despite the fact that the latter channel lies closer to the current active channel. Although there is extensive modification of the landscape by clearing of vegetation, agricultural activity, surface dumping, and construction of roads and drainage ditches, the only indication of buried cultural material was the presence of historic corroded nails and broken glass in the channel fill of the agricultural channel observed in Trench 14 (Feature 1).

General Site Formation and Preservation Principles

Relatively undisturbed archaeological sites are more likely to occur in the vertical accretion deposits of the floodplain (upper point bars, natural levees, crevasse splays, and oxbow lakes). For archaeological materials to become incorporated into these floodplain features, occupation must have taken place on the lowlands adjacent to the river channel during a period of geomorphic stability. After abandonment, the site would need to be inundated by low energy floodwaters and buried by fine-grained sediments (settling from suspension) during the waning stage of flow. Repeated periods of stability and reoccupation at an aggrading floodplain locale would create a stratified sequence of fine-grained sediment layers, sometimes with interbedded paleosols, or a cumulic soil profile (when the rate of deposition and soil formation are roughly coeval) that contains archaeological debris. Floodplain aggradation would cease if the river down-cut or if the river's flow regime is altered so that the lowlands adjacent to the channel are no longer flooded.

Vertical accretion also occurs along the channel margin on proximal point bar surfaces, natural levees, and crevasse splays. As they did on the floodplain, people likely occupied point bars during periods of stability and resultant sites were subsequently buried during low-energy overbank flooding. As a result of repeated cycles of point bar stability and overbank deposition, discrete occupation surfaces could be buried. If the intervals of stability were long and punctuated by infrequent episodes of deposition, multiple occupations by different groups would be superimposed on one another. Similar to the upper portions of point bars, natural levees and crevasse splays are incrementally built by vertical accretion during floods and may also contain archaeological materials.

Oxbow lake sediments may also contain archaeological sites. While cultural-use areas are commonly situated on the floodplain next to oxbow lakes, they may also be located in the abandoned oxbow channel floor during periods of low water. Such occupations were probably predicated on the fact that very small ponds remained in the oxbow. Evidence of this occupation could become buried when overbank floodwaters fill the abandoned meander, the recession of floodwaters causing suspended fine-grained sediments to settle from suspension and bury the site. Because of the low energy levels associated with the settling of suspended sediments, sites buried in oxbow lakes are generally well preserved (Waters 1992:142).

Archaeological sites are also found on and in river terraces. Whether a site occurs on the surface or is buried in a terrace deposit depends on the age of the terrace and the nature of the occupation. People that occupied the lower Colorado River valley likely camped on the active floodplain or any of the terraces that flanked it. In general, because terraces represent a chronological set of landforms—that progressively get younger toward the active channel—higher terraces situated further away from the active channel have been available for human occupation for longer periods of time than lower terraces situated closer to the active channel. Consequently, artifact assemblages resting on the surface of higher terraces normally contain a greater mixture of older and younger artifacts than younger and lower terraces. The mixture of temporally discrete assemblages should diminish close to the active channel.

So far, we have presented the positive preservational aspects of site formation on a floodplain. The context of sites on a floodplain, however, may also be partially or completely destroyed by water scouring during overbank flooding. Depending upon the site's location on the floodplain—coupled with the magnitude of the flood—surface or shallowly buried sites may be eroded and destroyed. Eroded site assemblages often exhibit distinctive spatial characteristics. Cobble tools and fire-cracked rock can be reworked into lines, and lighter bone material can be swept from a site (Waters 1992:143). However, small flakes lodged in the plant litter mat may remain in activity clusters. Size grading of artifacts would be another important line of evidence identifying eroded artifact assemblages.

Changes in the riverine environment are recorded in the stratigraphic record, which in turn is composed of sediments deposited during discrete intervals of time separated by periods of erosion, short episodes of nondeposition, and long periods of stability. Subsequently, the archaeological record contained in floodplain sediments often lacks the complete record of human use of a riverine setting. Occupational hiatuses at a specific locality or region are just as likely to be the result of erosion as they are of cultural process. Meaningful interpretations of prehistoric human behavior in riverine settings can only be made after the history of deposition, erosion, and stability are reconstructed.

Site Preservation Potential within the APE

Artificial levees were constructed alongside the lower Colorado River in the APE between 1907 and 1911, but prior to construction of Hoover and other dams upstream. Prior to dam construction, major floods occurred approximately every two years. These flood events essentially scoured the entire area between the levees prior to the dramatic reduction in river discharge following dam construction (see Figure 28). Consequently, the likelihood of identifying prehistoric archaeological materials in relatively undisturbed contexts between the artificial levees is exceptionally low. However, it is possible that historical-period sites and artifacts postdating dam construction exist on or in stabilized point bars, natural levees, or the low-lying terraces that currently flank the modern channel between the levees.

A greater potential exists for preserved prehistoric sites away from the modern channel beyond the artificial levees. Though the area east of the artificial levees has witnessed extensive cultivation, the possibility that prehistoric remains are buried beyond the levees remains. Archaeological remains could occur theoretically anywhere in this area; however, relict floodplain landforms such as large buried point bars, natural terraces and levees, and oxbow lakes were likely occupied prehistorically. Further, the sediments forming these features are generally deposited in low-energy overbank flooding episodes. As such, a greater potential exists for the preservation of relatively undisturbed cultural materials in these settings.

Conclusions

Developing a predictive model to forecast the location of cultural resources is predicated on many factors, the most important of which is the physical landscape. Settlement patterns among prehistoric and, to a lesser extent, historical-period peoples were intimately tied to and determined by their physical surroundings. During prehistory, the land represented life itself, and the an obvious key to survival was the successful adaptation and exploitation of the physical environment. Archaeological interpretation of the relationship of prehistoric peoples to their environment hinges on the ability to define both the nature and extent of environmental exploitation (as determined through the preservation and investigation of material culture) and the environment itself. If one of these key elements is removed from the interpretive equation, our ability to interpret or predict traditional cultural patterns is significantly hampered.

In the case of the lower Colorado River, both of these elements are compromised to some extent. Remnants of the physical exploitation of the environment has been removed through channel meander or buried under floodplain deposits. Additionally, the physical environment, although likely remaining relatively representative, has been heavily modified by agricultural use in the twentieth century.

Does this completely undermine our ability to predict prehistoric and historical-period site locations outside the confines of the levee system that currently channelizes the Colorado River? The answer, for all intents and purposes, is yes . . . and no. We can presume with a high degree of certainty that prehistoric groups used the lower Colorado River valley heavily, but understanding exactly how they interacted with their environment cannot be understood in the absence of cultural or environmental evidence. With the dearth of information currently available and the absence of any remnant topographic indicators, suggesting that the location of cultural resources can be predicted is presumptuous at best and foolhardy at worst.

Conclusions and Recommendations

This report provides background information, historical contexts, and documentation on known cultural resources within a 24-mile (38.4-km) corridor along the lower Colorado River (known as the international boundary segment), from Morelos Dam to the U.S.-Mexico southerly international border. This information will be used during the preparation of an environmental assessment by USACE and the IBWC. Information on recorded sites is the first step in assessing the impact of the proposed dredging activities on cultural resources.

A total of 21 archaeological sites are currently known to exist within the APE. Pedestrian survey of the area has been very light, with no more than 2–4 percent of the APE having been intensively surveyed for the presence of cultural resources. As reported in Chapter 5, only 8 sites have been recommended as eligible, potentially eligible for listing in the NRHP, with several identified as contributing elements to the potentially eligible YIP district.

Management Recommendations

Because of the paucity of survey, assessing the cultural sensitivity of other parts of the APE is somewhat problematic. While it is clear that the overwhelming majority of lands within the current APE are under active cultivation, compromising the effectiveness of pedestrian survey, clusters of historical-period sites have been identified in areas that have not been significantly impacted by agricultural concerns. Sterner identified the remnants of three historical-period sites in the area of Willits Check (Sterner and Bischoff 1998) while Hathaway and Stone (1994) identified five sites near the town of Gadsden, Arizona. Whether these clusters represent relatively dense historical-period use or are representative of archaeological coverage is impossible to determine without additional survey. Similarly, the small number of recorded sites in other areas of the APE cannot be taken as a proxy of limited prehistoric or historical-period use. Apart from these resources, the only other known archaeological resources within the APE are components of the YIP.

Understanding the difficulties of predicting the location of archaeological resources beneath actively cultivated areas, USACE also mandated that SRI implement a limited plan of subsurface testing in areas of the APE that may be impacted under the current, or any future, undertaking. The results of this investigation were presented in Chapter 6 of this document and suggest strongly that no intact prehistoric cultural resources remain within the levees that bound the Colorado River, although limited historical-period resources may exist within this corridor. Outside of the levees, predicting cultural resources is significantly hampered by the environmental and topographic manipulation resulting from a century of agricultural activity.

It should be added that no traditional cultural properties (TCPs) or traditional use areas (TUAs) were identified during the archival research conducted for this undertaking. While none have been officially recorded with the appropriate state agencies, care should be taken to contact representative Native American groups, who indicate an association with the lands falling within the APE, for information regarding these site types. If significant TCPs or TUAs are identified within impact areas, appropriate treatment plans will need to be devised.